PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2001-041736

(43)Date of publication of application : 16.02.2001

(51)Int.Cl. G01B 21/30
G01B 9/02
G01B 11/30
G01N 21/95
G01N 21/956
G11B 5/84
G11B 7/26

(21)Application number : 11-217439

(22)Date of filing : 30.07.1999

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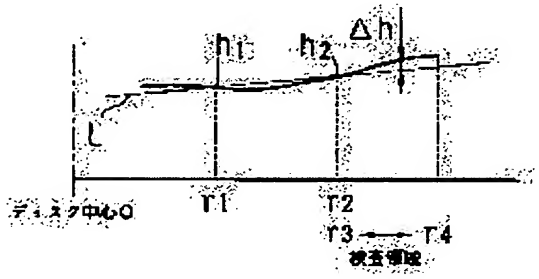
(54) SURFACE INSPECTION DEVICE AND METHOD AND RECORDING MEDIUM HAVING SURFACE INSPECTION PROGRAM RECORDED

(57)Abstract:

PROBLEM TO BE SOLVED: To enable easy inspection of sharp change of shape over the whole surface of sample, especially change of shape in an edge portion by performing analyzation on change of shape in an inspection region for every sectional shape based on a surface shape data in a region set in the vicinity of the inspection region.

SOLUTION: Vicinity regions γ1–γ2 are for example set at radius positions γ1, γ2 close to inspection regions γ3–γ4 for radius(r) sectional shape of a disk to be inspected, and a reference line L to connect respective surface shape positions h1, h2 at the respective radius positions γ1, γ2 is formed. By the use of this line L as the reference for calculating ski jump(SJ)/roll off(RO) in radius section of the disk, a protrusion deviation Δh (SJ value) and a recessed deviation h (RO value) with respect to the line L are obtained. Through such a sectional shape measurement is carried out at a plurality of angles from the center of the disk, the SJ value and RO value are calculated so as to evaluate the surface shape of the disk.



LEGAL STATUS

[Date of request for examination] 03.03.2000

[Date of sending the examiner's decision of rejection] 31.07.2002

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

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CLAIMS

[Claim(s)]
[Claim 1] A configuration data input means to input the surface type-like data of the whole sample surface, and a cross-section configuration calculation means to acquire the radial cross-section configuration of a sample for every predetermined include angle based on the inputted data, Surface-analysis equipment characterized by having a setting means to set up the near field close to an inspection zone and this inspection zone, an analysis means to ask for form status change-ization of said inspection zone for every cross-section configuration based on the surface type-like data of said set-up near field, and an output means to output this analysis result.
[Claim 2] The configuration data input means of claim 1 is surface-analysis equipment characterized by having the interference fringe means forming which forms an interference fringe by the reflected light from a sample front face and a reference side, an image acquisition means to capture the image of the formed interference fringe, and an operation means to ask for the surface type-like data on the front face of a sample based on the captured image.
[Claim 3] It is surface-analysis equipment characterized by creating the datum line for every cross-section configuration based on the surface type-like data in said near field to which said analysis means was set up in the surface-analysis equipment of claim 1, and calculating the amount of bias of said inspection zone to this datum line for every cross-section configuration.
[Claim 4] It is surface-analysis equipment characterized by creating the straight line determined by defining two points of surface type-like data [in / on the surface-analysis equipment of claim 3, and / in said analysis means / said near field] as the datum line.
[Claim 5] It is surface-analysis equipment characterized by said analysis means calculating each maximum of the amount of convex side bias of the formation of a form status change of said inspection zone, and the amount of concave side bias as an analysis result in the surface-analysis equipment of claim 1.
[Claim 6] It is surface-analysis equipment characterized by for said analysis means calculating each maximum of the amount of convex side bias of the formation of a form status change of said inspection zone, and the amount of concave side bias as an analysis result, and equipping said output means with a display means to display the sample cross-section configuration of having each maximum calculated by said analysis means, in the surface-analysis equipment of claim 1.
[Claim 7] The configuration data input phase of inputting the surface type-like data of the whole sample surface, and the cross-section configuration calculation phase of acquiring the radial cross-section configuration of a sample for every predetermined include angle based on the inputted data, The surface-analysis approach characterized by having the setting phase of setting up the near field close to an inspection zone and this inspection zone, and the analysis phase of asking for form status change-ization of said inspection zone for every cross-section configuration based on the surface type-like data of said set-up near field.
[Claim 8] In the record medium which recorded the surface-analysis program which inspects a sample front face The cross-section configuration calculation phase of acquiring the radial cross-section

configuration of a sample for every predetermined include angle based on the inputted data, The record medium which recorded the surface-analysis program characterized by having the setting phase of setting up the near field close to an inspection zone and this inspection zone, and the analysis phase of asking for form status change-ization of said inspection zone for every cross-section configuration based on the surface type-like data of said set-up near field.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the record medium which recorded the surface-analysis equipment, the surface-analysis approach, and surface-analysis program which inspect the shape of surface type of a sample.
[0002]
[Description of the Prior Art] In semi-conductor wear, an optical disk, a magnetic disk, etc., the shape of surface type influences the quality of a product greatly. In the hard disk (HDD) which applied the magnetic material to glass or an aluminum disk especially, since reading and record of data are performed in the condition that the about dozens of nm magnetic head has surfaced from a disk front face, if rapid concave heights exist in a front face, the magnetic head and a disk collide, and will not crash or reading and record of data will no longer be performed. In this case, measurement of the rapid formation of a form status change becomes important at the same time it gets to know the display flatness of the whole front face.
[0003] Moreover, rapid form status change-ization tends to appear in an edge part on the production process of a disk. The shape of surface type near an edge is estimated by the roll-off (henceforth RO) which shows the sagging condition of the edge section, and ski jumping (henceforth SJ) which shows the climax condition of the edge section.
[0004] Sensing-pin-type test equipment and the non-contact-type test equipment by an electrostatic-capacity probe etc. are known as a technique which measures the shape of surface type of such a sample conventionally. Sensing-pin type test equipment makes an one direction scan a sample top, where a needle is directly contacted on a sample front face, and measures the shape of surface type from vertical movement of a needle. Also in non-contact type test equipment, an one direction is made to scan a probe similarly and the shape of surface type is measured by detecting the distance on a probe and the front face of a sample.
[0005]
[Problem(s) to be Solved by the Invention] However, in the above test equipment, in order to make a needle and a probe scan at the time of inspection, only one cross section can be inspected to measurement by one scan, but inspection time amount becomes long. For this reason, even if many, only radial 8 cross-section extent was inspected, but it is still un-inspecting except an inspection cross section, and the defective part may have been overlooked.
[0006] Moreover, in sensing-pin type test equipment, since it measures by contacting a sample front face, a blemish may be attached to a sample front face.
[0007] Furthermore, since it is time and effort to perform such surface type-like measurement and the whole display flatness measurement with another test equipment, to carry out to coincidence is desired.
[0008] This invention makes it a technical technical problem to offer the surface-analysis equipment which crosses all over a sample and can inspect easily the rapid formation of a form status change, especially form status change-ization of an edge part in view of the trouble of the above-mentioned

conventional technique.
[0009]
[Means for Solving the Problem] In order to solve the above-mentioned technical problem, it is characterized by equipping this invention with the following configurations.
[0010] (1) A configuration data input means to input the surface type-like data of the whole sample surface, A cross-section configuration calculation means to acquire the radial cross-section configuration of a sample for every predetermined include angle based on the inputted data, It is characterized by having a setting means to set up the near field close to an inspection zone and this inspection zone, an analysis means to ask for form status change-ization of said inspection zone for every cross-section configuration based on the surface type-like data of said set-up near field, and an output means to output this analysis result.
[0011] (2) The configuration data input means of (1) is characterized by having the interference fringe means forming which forms an interference fringe by the reflected light from a sample front face and a reference side, an image acquisition means to capture the image of the formed interference fringe, and an operation means to ask for the surface type-like data on the front face of a sample based on the captured image.
[0012] (3) In the surface-analysis equipment of (1), said analysis means creates the datum line for every cross-section configuration based on the surface type-like data in said set-up near field, and it is characterized by calculating the amount of bias of said inspection zone to this datum line for every cross-section configuration.
[0013] (4) In the surface-analysis equipment of (3), it is characterized by said analysis means creating the straight line determined by defining two points of the surface type-like data in said near field as the datum line.
[0014] (5) In the surface-analysis equipment of (1), said analysis means is characterized by calculating each maximum of the amount of convex side bias of the formation of a form status change of said inspection zone, and the amount of concave side bias as an analysis result.
[0015] (6) In the surface-analysis equipment of (1), said analysis means calculates each maximum of the amount of convex side bias of the formation of a form status change of said inspection zone, and the amount of concave side bias as an analysis result, and said output means is characterized by having a display means to display the sample cross-section configuration of having each maximum calculated by said analysis means.
[0016] (7) The configuration data input phase of inputting the surface type-like data of the whole sample surface, The cross-section configuration calculation phase of acquiring the radial cross-section configuration of a sample for every predetermined include angle based on the inputted data, It is characterized by having the setting phase of setting up the near field close to an inspection zone and this inspection zone, and the analysis phase of asking for form status change-ization of said inspection zone for every cross-section configuration based on the surface type-like data of said set-up near field.
[0017] (8) In the record medium which recorded the surface-analysis program which inspects a sample front face The cross-section configuration calculation phase of acquiring the radial cross-section configuration of a sample for every predetermined include angle based on the inputted data, It is characterized by having the setting phase of setting up the near field close to an inspection zone and this inspection zone, and the analysis phase of asking for form status change-ization of said inspection zone for every cross-section configuration based on the surface type-like data of said set-up near field.
[0018]
[Embodiment of the Invention] Hereafter, 1 operation gestalt is mentioned about this invention, and it explains based on a drawing. Drawing 1 is the important section block diagram of surface-analysis equipment. The following explanation explains the case where it is aimed at the glass or the aluminum disk used for HDD as a test portion.
[0019] After the laser beam which carried out outgoing radiation from the helium-Ne laser light source 1 which is a source of a measuring beam passes the expander lens 2, it is made the parallel flux of light by the collimator lens 3, and carries out incidence to prism 4. Distance with measuring-plane-ed 6' of a disk

6 is changed by the piezo-electric element 5, and, as for reference side 4' of prism 4, the phase of a reference beam changes.

[0020] It reflects by measuring-plane-ed 6' of the disk 6 which penetrated reference side 4' and was laid in the installation base 7, and a part of light which carried out incidence to prism 4 passes prism 4 again, and it faces to a screen 8. The light reflected by reference side 4' on the other hand among the light which carried out incidence to prism 4 is projected on a lifting and a screen 8 toward a screen 8 in the light and the interference phenomenon which were reflected by measuring-plane-ed 6'.

[0021] Image formation of the interference fringe projected on the screen 8 is carried out to the image pick-up side of a camera 10 with a lens 9, and it is picturized. The picturized interference fringe is transmitted to analysis equipment 11 as a video signal, and various kinds of operation analyses are performed. The monitor 12 which displays input section 11a, such as a keyboard and a mouse, a photography image, and an analysis result is connected to analysis equipment 11. 13 is a control section and performs drive control of a laser light source 1 and piezo-electric element 5 grade.

[0022] In surface-analysis equipment equipped with the above configurations, it is based on the flow chart Fig. of drawing 2 , and the actuation is explained below.

[0023] After laying a disk 6 in the installation base 7, it puts on a predetermined measuring point. A laser beam is emitted by control of a control section 13 from a laser light source 1, and the interference fringe formed of the light reflected by reference side 4' and measuring-plane-ed 6' is projected on a screen 8. Moreover, a control section 13 impresses an electrical potential difference to a piezo-electric element 5, is changing the distance of reference side 4' and measuring-plane-ed 6', and changes the phase of an interference fringe. In this way, the interference fringe image from which the phase changed is picturized with a camera 10, and each image data is incorporated by the memory in analysis equipment 11. In addition, with a phase shift interference method, the number of phase shifts is usually performed at four or more steps.

[0024] After analysis equipment 11 processes common knowledge at two or more interference fringe images with which the phases incorporated in memory differ, such as noise rejection, it determines a disk field based on the amplitude obtained in phase shift analysis, and performs connector doubling of a phase based on this. And the surface three-dimensions configuration of measuring-plane-ed 6' is computed by changing this phase data into height data. In addition, refer to JP,10-221033,A by these people for the detail of the analysis by this phase shift method. The computed three-dimensions configuration is displayed on a monitor 12 with a bird's-eye view, a contour map, etc., and a ** person can evaluate the display flatness of whole measuring-plane-ed 6'.

[0025] Next, the case where SJ/RO is evaluated is explained. By input section 11a, the parameter of SJ/RO displayed on a monitor 12 is chosen, and the radius locations r1 and r2 for the metrics line creation in a radial cross section and the radius locations r3 and r4 of the inspection zone of SJ/RO are inputted as an input of a Measuring condition. r1, r2, r3, and r4 show the distance from a disk core, respectively. For example, in measurement of SJ/RO of the periphery edge section, r4 takes r3 from there to 3mm inside for the outermost periphery. r1 is taken in the distance as r3 with r2 [same] at r2 to 4mm inside as a near field where r1 and r2 approach among rinspection zone r3-4. In addition, it includes in the program beforehand by making these [r1 r2, r3, and r4] into a fixed value, and only when inspecting an arbitration location, it may be made to make a numerical change.

[0026] Analysis of SJ/RO is performed by this condition input. Hereafter, the analysis of SJ/RO is explained based on the mimetic diagram of the cross-section configuration of drawing 3 . First, it asks for the datum line L which connects the surface type-like locations h1 and h2 in the radius locations r1 and r2 about the cross section in the include angle theta 1 of measurement initiation. This datum line L serves as criteria of SJ/RO calculation in a disk radial cross section, and the amount [as opposed to SJ value and a datum line L for the amount of convex side bias to a datum line L] of concave side bias is calculated as a RO value. If the disk front face is changing gently-sloping, although the magnetic head can be followed, if the front face is changing rapidly, crash of the magnetic head and a disk will not arise or reading and record of data will not be performed. Therefore, by being near the inspection zones r3-r4, and taking r1 and r2 which create the datum line L in the small section according to the flattery property

of the magnetic head, it is not influenced by bending of an entire disk etc. but extent of the abrupt change of an inspection zone can be measured. Moreover, the datum line L may be obtained as a minimum square straight line between h1 - h2.

[0027] Next, it asks for surface type-like difference (amount of bias) deltah to the datum line L among r3-r4 which are an inspection zone. After computing amount of bias deltah in the field of r3-r4 in order, deltahmax (maximum of plus) and deltahmin (maximum of minus) used as the maximum of SJ value in this cross section and RO value are respectively set to SJ1 and RO1, and it memorizes as SJmax and ROmax, respectively.

[0028] If SJmax (SJ1) and ROmax (RO1) in the cross section in an include angle theta 1 are computed, the cross-section information on the following include angle theta 2 will be extracted, deltahmax and deltahmin will be computed like the above after calculation of the datum line L by r1 and r2 in the cross section, and it will be referred to as SJ2 and RO2, respectively. And SJmax and ROmax which were previously remembered to be SJ2 and RO2 are compared, and the updating storage of the one where a value is larger is carried out as SJmax and ROmax.

[0029] A sequential change of the include angle theta which extracts cross-section information is made hereafter, SJ value and RO value are computed about the cross section in every include angle, and SJmax and ROmax to the perimeter are obtained by updating as compared with SJmax and ROmax. Thus, the SJmax value and ROmax value over the whole sample surface can be easily acquired in analyzing based on the three-dimensions surface type-like data obtained from an interferometer.

[0030] In addition, although the include angle of the cross section which analyzes may be performed the whole predetermined include angle (every [for example,] degree), it constitutes from this operation gestalt so that it may analyze by making into a measurement cross section the straight line in which the outside edge EO exists and which is connected to the pixel and disk core O for every pixel.

[0031] In this way, on the screen of a monitor 12, analysis of SJmax and ROmax to the perimeter displays the cross-section configuration of each cross section with SJmax and ROmax, as shown in drawing 4 (a) and (b). The include angle theta of each cross-section configuration, a SJmax value, a ROmax value, etc. are displayed on each display. The location with the SJmax value of each cross section and a ROmax value is shown by Marks 20a and 20b, respectively. In addition, in the display of drawing 4 (a) and the cross-section configuration of (b), the level criteria (0 locations) of an axis of ordinate are displayed on the basis of the virtual flat surface searched for with the least square method based on all sample surface type-like data.

[0032] Moreover, as shown in drawing 5 , on the high diagram 30, such as having been displayed as an analysis result of display flatness, the location of SJmax is shown by mark 31a and the location of ROmax is shown by mark 31b.

[0033] Thus, if the include angle for which it asks by input section 11a further is specified to the analyzed result, the cross-section configuration in the include angle theta specified by analysis equipment 11, a SJmax value, and a ROmax value will be calculated, and the result in an arbitration include angle will be displayed on a monitor 12.

[0034] Moreover, as an analysis result, various kinds of modification is possible as follows. For example, when SJ value and RO value want to know a part 0.1 micrometers or more, that distribution condition is displayed on the high diagram 30, such as having been shown in drawing 5 , by inputting this condition.

[0035] A ** person can evaluate the shape of surface type of a disk by the cross-section configuration displayed on a monitor 12 as mentioned above, SJ value, and RO value. Moreover, since the location of SJmax and ROmax to a whole configuration (three-dimensions configuration) is displayed, the relevance of display flatness, and SJ and RO can also be known. Furthermore, it can use for a production control, the improvement of a production process, etc. by creating the distribution map based on the result of SJ value over the whole surface, and RO value, or taking statistics.

[0036]

[Effect of the Invention] As explained above, according to this invention, it can cross all over a sample, SJ value and RO value can be acquired easily, and the maximum, a cross-section location, etc. can be

obtained easily. Furthermore, an inspection sample is not damaged for non-contact. Moreover, one equipment can also perform display flatness measurement of a sample.

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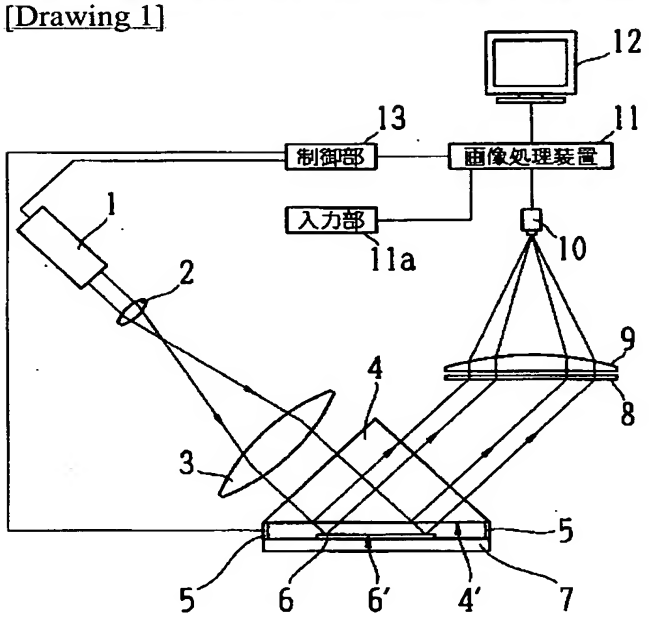
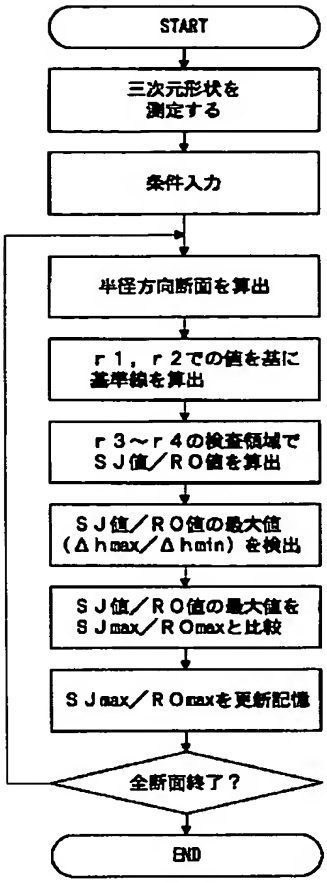
DRAWINGS

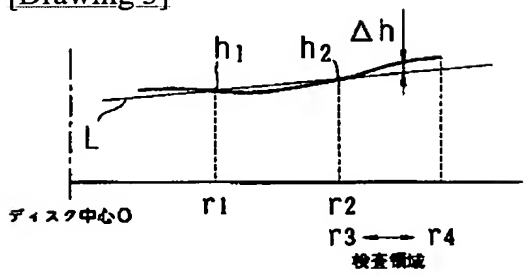
[Drawing 1]



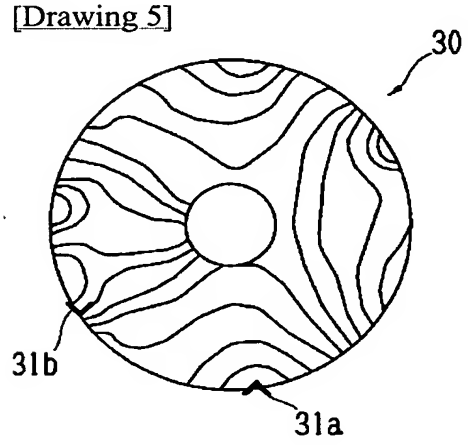
[Drawing 2]



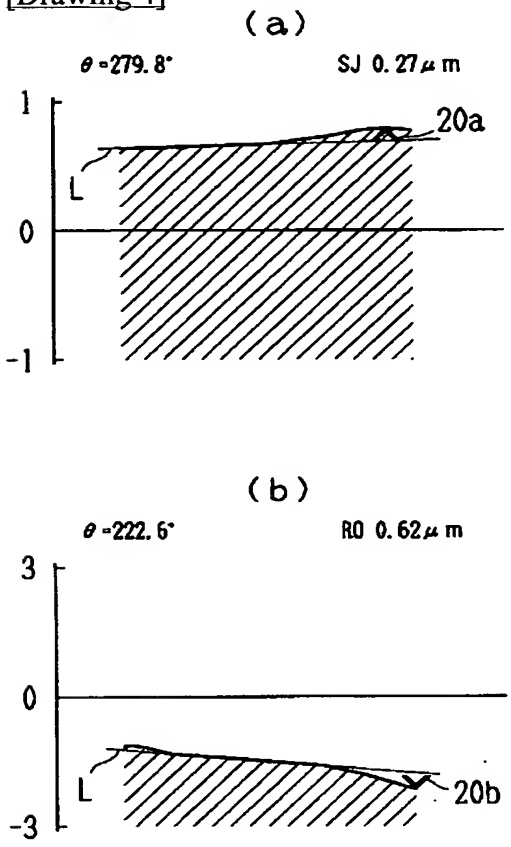
[Drawing 3]



[Drawing 5]



[Drawing 4]



[Translation done.]

(19)日本国特許庁（ＪＰ）　(12)公開特許公報（Ａ）　(11)特許出願公開番号
特開2001－41736
（P2001－41736A）
(43)公開日　平成13年２月16日(2001.2.16)

(51)Int.Cl.'	識別記号	FI		テーマコード'(参考)
G01B 21/30	101	G01B 21/30	101F	2F064
9/02		9/02		2F065
11/30	101	11/30	101A	2F069
G01N 21/95		G01N 21/95	A	2G051
21/956		21/956	A	5D112

審査請求　有　請求項の数８　ＯＬ　（全 6 頁）　最終頁に続く

(21)出願番号　特願平11－217439

(22)出願日　平成11年７月30日(1999.7.30)

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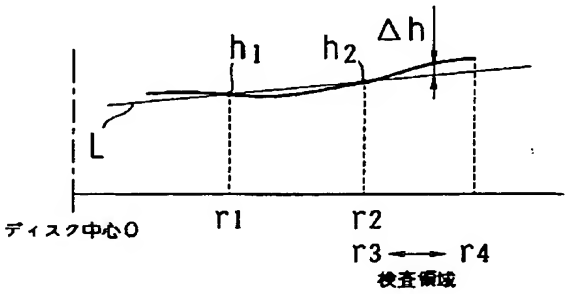
最終頁に続く

(54)【発明の名称】　表面検査装置、表面検査方法及び表面検査プログラムを記録した記録媒体

(57)【要約】
【課題】　試料全面に渡って急激な形状変化、特にエッジ部分の形状変化を、容易に検査できる。
【解決手段】　入力された試料全面の表面形状データに基づいて試料の半径方向の断面形状を所定角度毎に得て、検査領域の形状変化を検査領域に近接する近傍領域の表面形状データに基づいて各断面形状毎に求める解析する。



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【特許請求の範囲】

【請求項１】　試料全面の表面形状データを入力する形状データ入力手段と、入力されたデータに基づいて試料の半径方向の断面形状を所定角度毎に得る断面形状算出手段と、検査領域と該検査領域に近接する近傍領域を設定する設定手段と、設定された前記近傍領域の表面形状データに基づいて前記検査領域の形状変化を各断面形状毎に求める解析手段と、該解析結果を出力する出力手段と、を備えることを特徴とする表面検査装置。

【請求項２】　請求項１の形状データ入力手段は、試料表面と参照面からの反射光とによって干渉縞を形成する干渉縞形成手段と、形成された干渉縞の画像を取り込む画像取得手段と、取り込んだ画像を基に試料表面の表面形状データを求める演算手段と、を備えることを特徴とする表面検査装置。

【請求項３】　請求項１の表面検査装置において、前記解析手段は設定された前記近傍領域における表面形状データに基づいて断面形状毎に基準線を作成し、該基準線に対する前記検査領域の偏位量を各断面形状毎に求めることを特徴とする表面検査装置。

【請求項４】　請求項３の表面検査装置において、前記解析手段は前記近傍領域における表面形状データの２点を定めることによって決定される直線を基準線として作成することを特徴とする表面検査装置。

【請求項５】　請求項１の表面検査装置において、前記解析手段は解析結果として前記検査領域の形状変化の凸側偏位量と凹側偏位量の各最大値を求めることを特徴とする表面検査装置。

【請求項６】　請求項１の表面検査装置において、前記解析手段は解析結果として前記検査領域の形状変化の凸側偏位量と凹側偏位量の各最大値を求め、前記出力手段は前記解析手段により求められた各最大値を有する試料断面形状を表示する表示手段を備えることを特徴とする表面検査装置。

【請求項７】　試料全面の表面形状データを入力する形状データ入力段階と、入力されたデータに基づいて試料の半径方向の断面形状を所定角度毎に得る断面形状算出段階と、検査領域と該検査領域に近接する近傍領域を設定する設定段階と、設定された前記近傍領域の表面形状データに基づいて前記検査領域の形状変化を各断面形状毎に求める解析段階と、を備えることを特徴とする表面検査方法。

【請求項８】　試料表面を検査する表面検査プログラムを記録した記録媒体において、入力されたデータに基づいて試料の半径方向の断面形状を所定角度毎に得る断面形状算出段階と、検査領域と該検査領域に近接する近傍領域を設定する設定段階と、設定された前記近傍領域の表面形状データに基づいて前記検査領域の形状変化を各断面形状毎に求める解析段階と、を備えることを特徴とする表面検査プログラムを記録した記録媒体。

2

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は試料の表面形状を検査する表面検査装置、表面検査方法及び表面検査プログラムを記録した記録媒体に関する。

【０００２】

【従来技術】半導体ウェア、光ディスク、磁気ディスク等においては表面形状が製品の品質に大きく影響する。殊にガラス又はアルミニウムディスクに磁性材料を塗布したハードディスク（ＨＤＤ）では、磁気ヘッドがディスク表面から数十ｎｍ程度浮上している状態でデータの読取・記録が行われるため、表面に急激な凹凸部が存在すると、磁気ヘッドとディスクが衝突してクラッシュしたり、データの読取・記録が行われなくなる可能性がある。この場合、表面全体の平坦度を知ると同時に、急激な形状変化の測定が重要となってくる。

【０００３】また、急激な形状変化はディスクの製造工程上、エッジ部分に現われやすい。エッジ付近の表面形状は、エッジ部のダレ具合を示すロールオフ（以下、ＲＯという）と、エッジ部の盛り上がり具合を示すスキージャンプ（以下、ＳＪという）によって評価される。

【０００４】従来、このような試料の表面形状を測定する技術として触針式の検査装置や、静電容量プローブ等による非接触式の検査装置が知られている。触針式検査装置は針を試料表面に直接接触させた状態で試料上を一方向に走査させ、針の上下動から表面形状を測定する。非接触式検査装置においても、同様にプローブを一方向に走査させ、プローブと試料表面との距離を検出することで表面形状を測定している。

【０００５】

【発明が解決しようとする課題】しかしながら、上記のような検査装置では検査時に針やプローブを走査させる必要があるため、１回の走査による測定に対して１断面しか検査することができず、検査時間が長くなる。このため、多くても半径方向の８断面程度しか検査しておらず、検査断面以外については未検査のままであり、欠陥部を見落としてしまう可能性があった。

【０００６】また、触針式検査装置では試料表面に接触して測定を行うため、試料表面に傷が付く可能性がある。

【０００７】さらに、このような表面形状測定と全体の平坦度測定を別の検査装置で行うことは手間であるので、同時に行うことが望まれている。

【０００８】本発明は上記従来技術の問題点を鑑み、試料全面に渡って急激な形状変化、特にエッジ部分の形状変化を、容易に検査できる表面検査装置を提供することを技術課題とする。

【０００９】

【課題を解決するための手段】上記課題を解決するために、本発明は以下のような構成を備えることを特徴とす

る。

【００１０】（１）　試料全面の表面形状データを入力する形状データ入力手段と、入力されたデータに基づいて試料の半径方向の断面形状を所定角度毎に得る断面形状算出手段と、検査領域と該検査領域に近接する近傍領域を設定する設定手段と、設定された前記近傍領域の表面形状データに基づいて前記検査領域の形状変化を各断面形状毎に求める解析手段と、該解析結果を出力する出力手段と、を備えることを特徴とする。

【００１１】（２）　（１）の形状データ入力手段は、試料表面と参照面からの反射光とによって干渉縞を形成する干渉縞形成手段と、形成された干渉縞の画像を取り込む画像取得手段と、取り込んだ画像を基に試料表面の表面形状データを求める演算手段と、を備えることを特徴とする。

【００１２】（３）　（１）の表面検査装置において、前記解析手段は設定された前記近傍領域における表面形状データに基づいて断面形状毎に基準線を作成し、該基準線に対する前記検査領域の偏位量を各断面形状毎に求めることを特徴とする。

【００１３】（４）　（３）の表面検査装置において、前記解析手段は前記近傍領域における表面形状データの２点を定めることによって決定される直線を基準線として作成することを特徴とする。

【００１４】（５）　（１）の表面検査装置において、前記解析手段は解析結果として前記検査領域の形状変化の凸側偏位量と凹側偏位量の各最大値を求めることを特徴とする。

【００１５】（６）　（１）の表面検査装置において、前記解析手段は解析結果として前記検査領域の形状変化の凸側偏位量と凹側偏位量の各最大値を求め、前記出力手段は前記解析手段により求められた各最大値を有する試料断面形状を表示する表示手段を備えることを特徴とする。

【００１６】（７）　試料全面の表面形状データを入力する形状データ入力段階と、入力されたデータに基づいて試料の半径方向の断面形状を所定角度毎に得る断面形状算出段階と、検査領域と該検査領域に近接する近傍領域を設定する設定段階と、設定された前記近傍領域の表面形状データに基づいて前記検査領域の形状変化を各断面形状毎に求める解析段階と、を備えることを特徴とする。

【００１７】（８）　試料表面を検査する表面検査プログラムを記録した記録媒体において、入力されたデータに基づいて試料の半径方向の断面形状を所定角度毎に得る断面形状算出段階と、検査領域と該検査領域に近接する近傍領域を設定する設定段階と、設定された前記近傍領域の表面形状データに基づいて前記検査領域の形状変化を各断面形状毎に求める解析段階と、を備えることを特徴とする。

【００１８】

【発明の実施の形態】以下、本発明について一実施形態を挙げ、図面に基づいて説明する。図１は表面検査装置の要部構成図である。以下の説明では、測定試料としてＨＤＤに使用されるガラス又はアルミニウムディスクを対象とした場合について説明する。

【００１９】測定光源であるHe－Neレーザ光源１から出射したレーザ光はエキスバンダレンズ２を通過した後、コリメータレンズ３により平行光束とされプリズム４に入射する。プリズム４の参照面４′はピエゾ素子５によりディスク６の被測定面６′との距離が変えられ、参照光の位相が変化される。

【００２０】プリズム４に入射した光の一部は参照面４′を透過して載置台７に載置されたディスク６の被測定面６′で反射し、再びプリズム４を通過してスクリーン８に向かう。一方、プリズム４に入射した光の内、参照面４′で反射した光はスクリーン８に向かい、被測定面６′で反射した光と干渉現象を起こし、スクリーン８に投影される。

【００２１】スクリーン８に投影された干渉縞はレンズ９によりカメラ１０の撮像面に結像し、撮像される。撮像された干渉縞は映像信号として解析装置１１に送信され、各種の演算解析が行われる。解析装置１１にはキーボードやマウス等の入力部１１ａ、撮影画像や解析結果を表示するモニタ１２が接続されている。１３は制御部で、レーザ光源１、ピエゾ素子５等の駆動制御を行う。

【００２２】以上のような構成を備える表面検査装置において、その動作を図２のフローチャート図に基づいて以下に説明する。

【００２３】ディスク６を載置台７に載置した後、所定の測定位置に置く。制御部１３の制御によりレーザ光源１からレーザ光が発せられ、参照面４′と被測定面６′で反射した光とにより形成される干渉縞がスクリーン８に投影される。また、制御部１３はピエゾ素子５に電圧を印加し、参照面４′と被測定面６′との距離を変化させることで、干渉縞の位相を変化させる。こうして位相が変化した干渉縞像がカメラ１０によって撮像され、各画像データは解析装置１１内のメモリに取り込まれる。なお、通常、位相シフト干渉法では、位相シフトの数を４ステップ以上で行う。

【００２４】解析装置１１はメモリに取り込んだ位相の異なる複数の干渉縞画像にノイズ除去等の周知の処理を施した後、位相シフト解析によって得られる振幅を基にディスク領域を決定し、これを基に位相の繋ぎ合わせを行う。そしてこの位相データを高さデータに変換することによって被測定面６′の表面三次元形状を算出する。なお、この位相シフト法による解析の詳細は、本出願人による特開平１０－２２１０３３号公報を参照されたい。算出された三次元形状は、鳥瞰図や等高線図等でモニタ１２に表示され、検者は被測定面６′の全体の平坦

度を評価できる。

【００２５】次に、ＳＪ／ＲＯの評価を行う場合について説明する。入力部１１ａにより、モニタ１２に表示されるＳＪ／ＲＯの測定項目を選択し、測定条件の入力として、半径方向の断面における測定基準線作成のための半径位置ｒ１，ｒ２、及びＳＪ／ＲＯの検査領域の半径位置ｒ３，ｒ４を入力する。ｒ１，ｒ２，ｒ３，ｒ４はそれぞれディスク中心からの距離を示す。例えば、外周エッジ部のＳＪ／ＲＯの測定では、ｒ４は最外周にとり、ｒ３はそこから３ｍｍ内側にとる。ｒ１，ｒ２は検査領域ｒ３－ｒ４間に近接する近傍領域として、ｒ２はｒ３と同じ距離に、ｒ１はｒ２から４ｍｍ内側にとる。なお、これらｒ１，ｒ２，ｒ３，ｒ４を固定値として予めプログラムに組込んでおき、任意位置を検査する場合のみ、数値変更を行うようにしてもよい。

【００２６】この条件入力によってＳＪ／ＲＯの解析が行われる。以下、図３の断面形状の模式図を基にＳＪ／ＲＯの解析について説明する。まず、測定開始の角度θ１における断面について、半径位置ｒ１，ｒ２での表面形状位置ｈ１，ｈ２を繋ぐ基準線Ｌを求める。この基準線Ｌはディスク半径方向の断面でのＳＪ／ＲＯ算出の基準となり、基準線Ｌに対する凸側偏位量をＳＪ値、基準線Ｌに対する凹側偏位量をＲＯ値として求める。ディスク表面がなだらかに変化していれば磁気ヘッドは追従できるが、表面が急激に変化していると、磁気ヘッドとディスクのクラッシュが生じたり、データの読取・記録が行われなくなる。よって、基準線Ｌを作成するｒ１，ｒ２を検査領域ｒ３～ｒ４の近傍で、かつ磁気ヘッドの追従特性に応じた小区間で取ることにより、ディスク全体の撓み等に影響されず、検査領域の急激な変化の程度を測定することができる。また、基準線Ｌはｈ１～ｈ２間の最小二乗直線として得てもよい。

【００２７】次に、基準線Ｌに対する表面形状の差（偏位量）Δｈを検査領域であるｒ３～ｒ４の間で求める。ｒ３～ｒ４の領域での偏位量Δｈを順に算出した後、この断面内でのＳＪ値及びＲＯ値の最大値となるΔh_{max}（プラスの最大値）及びΔh_{min}（マイナスの最大値）を各々SJ_1及びRO_1とし、それぞれSJ_{max}，RO_{max}として記憶する。

【００２８】角度θ１における断面でのＳJ_{max}（SJ_1）及びRO_{max}（RO_1）を算出したら、次の角度θ２の断面情報を抽出し、その断面内でｒ１，ｒ２による基準線Ｌの算出後、上記同様にΔh_{max}及びΔh_{min}を算出し、それぞれSJ_2及びRO_2とする。そして、SJ_2，RO_2と先に記憶したSJ_{max}，RO_{max}を比較し、値の大きいほうをSJ_{max}，RO_{max}として更新記憶する。

【００２９】以下、断面情報を抽出する角度θを順次変更し、各角度毎における断面についてＳＪ値及びＲＯ値を算出し、SJ_{max}及びRO_{max}と比較、更新することで、全周に対するSJ_{max}及びRO_{max}を得る。このようにして、干渉計から得られる三次元表面形状データを基に解析することで、容易に試料全面に対するSJ_{max}値、RO_{max}値を得ることができる。

【００３０】なお、解析を行う断面の角度は所定角度毎（例えば、１度毎）で行ってもよいが、本実施形態では外側端部ＥＯが存在する画素毎に、その画素とディスク中心Ｏと結ぶ直線を測定断面として解析を行うように構成している。

【００３１】こうして全周に対するSJ_{max}及びRO_{max}が解析されると、モニタ１２の画面上には、図４（ａ）及び（ｂ）に示すように、SJ_{max}、RO_{max}を持つ各断面の断面形状が表示される。各表示には各断面形状の角度θ、SJ_{max}値、RO_{max}値等が表示される。各断面のSJ_{max}値、RO_{max}値を持つ位置は、それぞれマーク２０ａ、２０ｂにより示される。なお、図４（ａ）及び（ｂ）の断面形状の表示においては、縦軸の水平基準（０の位置）は試料表面形状の全データを基に最小二乗法により求めた仮想平面を基準として表示している。

【００３２】また、図５に示すように、平坦度の解析結果として表示された等高線図３０上には、SJ_{max}の位置がマーク３１ａで、RO_{max}の位置がマーク３１ｂで示される。

【００３３】このように解析された結果に対し、さらに入力部１１ａによって所望する角度を指定すれば、解析装置１１によって指定された角度θにおける断面形状、SJ_{max}値、RO_{max}値が計算され、任意角度での結果がモニタ１２に表示される。

【００３４】また、解析結果としては、次のように各種の変更が可能である。例えば、ＳＪ値やＲＯ値が０．１μｍ以上の部分を知りたいときには、この条件を入力することにより、図５に示した等高線図３０上に、その分布状態が表示されるようにする。

【００３５】以上のようにしてモニタ１２に表示される断面形状やＳＪ値，ＲＯ値によって、検者はディスクの表面形状を評価することができる。また、全体形状（三次元形状）に対するSJ_{max}、RO_{max}の位置が表示されるので、平坦度とＳＪ，ＲＯとの関連性も知ることができる。さらに、全面に対するＳＪ値，ＲＯ値の結果を基にした分布図を作成したり、統計を取ることにより生産管理や生産工程の改善等に利用することができる。

【００３６】

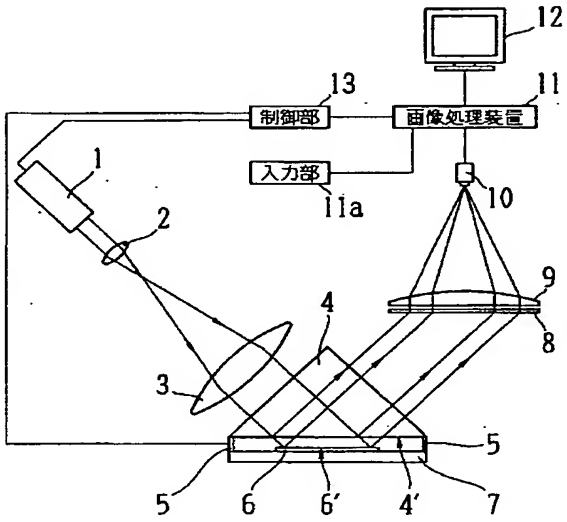
【発明の効果】以上説明したように本発明によれば、試料全面に渡って、ＳＪ値及びＲＯ値を容易に得ることができ、その最大値及び断面位置等を容易に得ることができる。さらに、非接触のため、検査試料を傷つけることがない。また、試料の平坦度測定も１台の装置で行える。

【図面の簡単な説明】

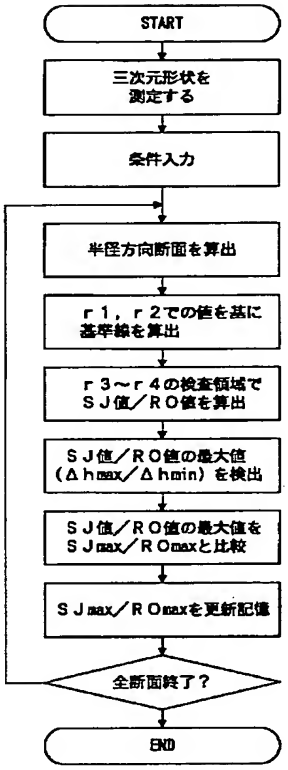
【図１】表面検査装置の要部構成図である。

【図２】表面検査のフローチャート図である。
【図３】ＳＪ／ＲＯの検出方法の説明図である。
【図４】断面形状の表示例である。
【図５】等高線図上のＳＪ／ＲＯの表示例である。
【符号の説明】
4′　参照面
6　ディスク
＊６′　被測定面
１１　画像処理装置
１２　モニタ
１３　制御部
２０ａ，２０ｂ　マーク
３１ａ，３１ｂ　マーク
＊　Ｌ　基準線

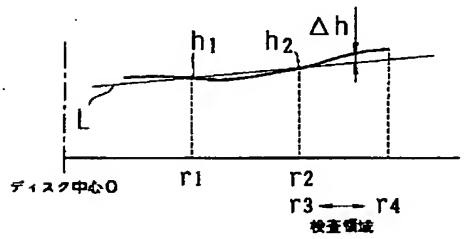
【図１】



【図２】



【図３】



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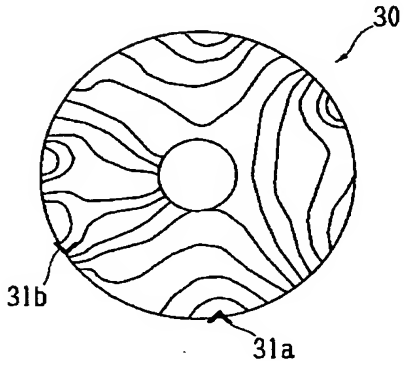

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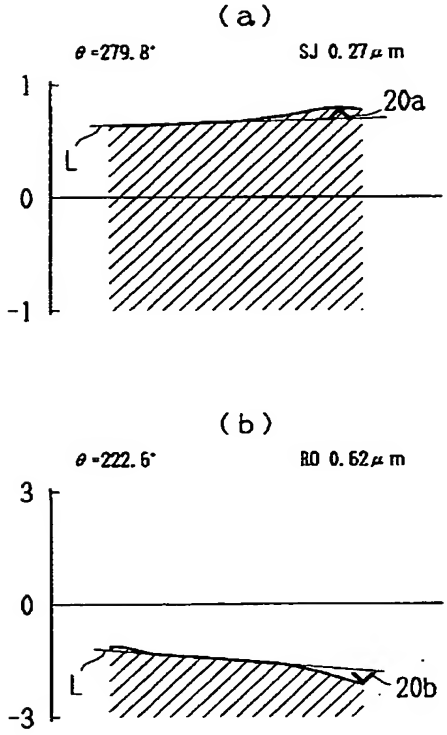

フロントページの続き

(51)Int.Cl.'	識別記号	FI	テーマコード(参考)
G11B 5/84		G11B 5/84	C 5D121
7/26		7/26	

Fターム(参考)　2F064 AA09 BB07 EE10 FF02 GG13
GG51 HH03 HH08 HH09 JJ01
2F065 AA47 AA49 CC03 CC19 DD06
FF04 FF52 GG05 HH03 HH12
JJ03 JJ19 JJ26 LL04 LL09
LL46 LL49 QQ13 QQ28 QQ31
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2F069 AA54 AA60 BB15 BB17 CC07
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2G051 AA51 AA71 AB02 AB07 BA10
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